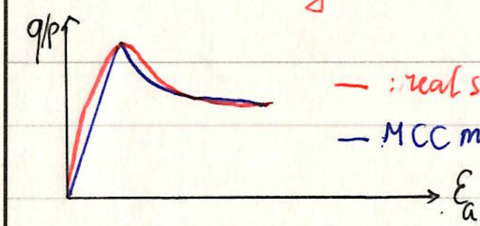
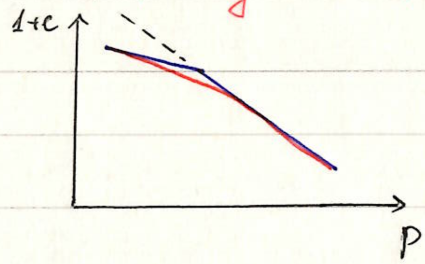
Subloading Modified Cam Clay model (1)

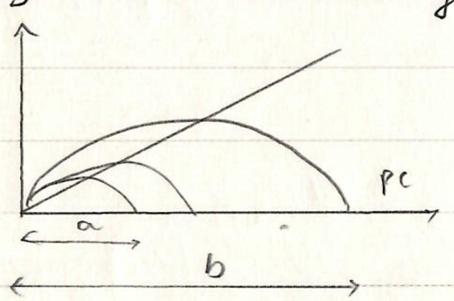


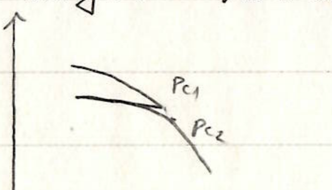


_ In Modified Cam Clay model. when the soil moves from overconsolidated state to the yield surface, soil obeys elastic stress-strain relationship. However as shown in experimental tests, plastic strain can be observed. Thus, there is a need to modyfied this model.

_ The important feature to capture is that: plastic strain occurs all the time & as soil's OC state is far away from NCL, ε^p is small compared with ε^e and when soil's state is near NCL, ε^p is larger in %.

_ Hashiguchi proposed a subloading surface in which ε^p can be determined by the ratio of the size between subloading yield surface & Yield surface $\frac{a}{b}$





However, in real soil behavior (4) can be seen which ≠ preconsolidation pressure: $p_{c_1} \neq p_{c_2}$

_ Kikumoto 先生 proposed the state parameter.

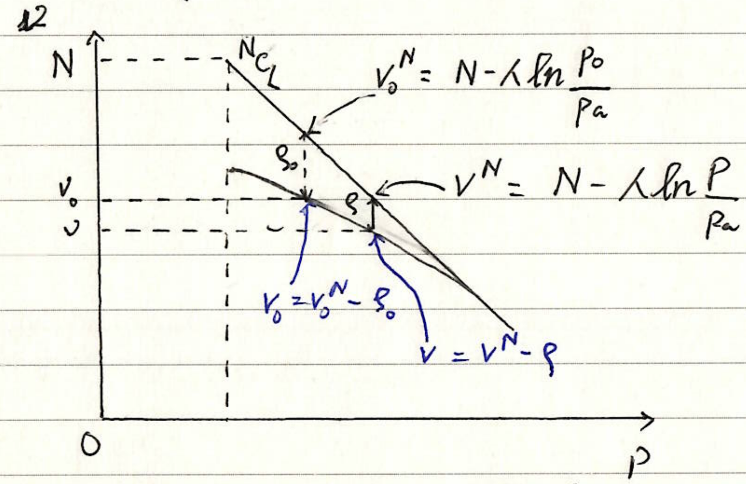
$$\rho = -e_{current} + e_{NCL\ at\ same\ p}$$

Subloading Modified Cam Clay model

- f is always $= 0$
- ε^p always $\neq 0$
- Unloading → elastic behavior only
- Reloading: $\dot{\varepsilon}^p \neq 0$

ρ — small: $\dot{\varepsilon}^p > \dot{\varepsilon}^e$

ρ — large: $\dot{\varepsilon}^e > \dot{\varepsilon}^p$



- $v_0 = v_0^N - \rho_0 = N - \lambda \ln \frac{p_0}{p_a} - \rho_0$
- $v = v^N - \rho = N - \lambda \ln \frac{p}{p_a} - \rho$
- $\Delta v = v - v_0 = -\lambda \ln \frac{p}{p_0} - (\rho - \rho_0)$
- $\varepsilon_v = -\frac{\Delta v}{v_0} = \frac{\lambda}{v_0} \ln \frac{p}{p_0} + \frac{\rho - \rho_0}{v_0}$
- $\varepsilon_v^e = \frac{\kappa}{v_0} \ln \frac{p}{p_0}$

$$\Rightarrow \varepsilon_v^p = \varepsilon_v - \varepsilon_v^e = \frac{\lambda - \kappa}{v_0} \ln \frac{p}{p_0} + \frac{\rho - \rho_0}{v_0}$$

$$\Rightarrow f = \frac{\lambda - \kappa}{v_0} \ln \frac{p}{p_0} + \frac{\rho - \rho_0}{v_0} - \varepsilon_v^p$$

Consistency Condition:

$$df = 0$$

$$\Leftrightarrow \underbrace{\frac{\partial f}{\partial \sigma}}_{\text{same as MCC}} d\sigma + \underbrace{\frac{\partial f}{\partial \rho}}_{\frac{1}{v_0}} \underbrace{d\rho}_{\text{unknown}} + \underbrace{\frac{\partial f}{\partial \varepsilon_v^p}}_{-1} \underbrace{d\varepsilon_v^p}_{\Lambda \frac{\partial f}{\partial \sigma}} = 0$$

Subloading Modified Cam Clay model ③

* The evolution law of state variable ρ:

- In constitutive model research, there are 2 main jobs:
  ① Find a reasonable variable
  ② Find its evolutional law

* Analysing process to find $d\rho$.

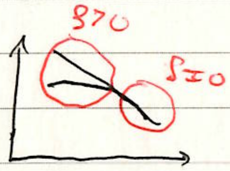
① when ε^p occurs, $\rho \downarrow$

$$\Rightarrow d\rho \sim -\|d\varepsilon^p\|$$

② If we directly use

$$d\rho = -\|d\varepsilon^p\| \text{ then } \rho \to <0$$

→ not ok.



③ We use a modified version:

$$d\rho = -\|d\varepsilon^p\|\,\rho$$

. when $\rho < 0$, very small $\Rightarrow d\rho > 0$. Finally: $\rho \to 0$
. when $\rho > 0$, " $d\rho < 0$. Finally $\rho \to 0$

④ To control the rate of convergence to 0, we use one more variable "a":

$$d\rho = -a\|d\varepsilon^p\|\,\rho$$

In practice, we use:

$$d\rho = -a\|d\varepsilon^p\|\,\rho\|\rho\|$$